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VI.

A D D R E S S .

BY DR. F. V. HAYDEN.

OUR GREAT WEST, AND THE SCENERY OF OUR NATURAL PARKS.

A large audience assembled at Association Hall, Wednesday evening, April 15th, to listen to Dr. F. V. Hayden; Chief-Justice DALY in the chair. After a few introductory remarks by the President, he said :

MR. PRESIDENT, FELLOWS OF THE AMERICAN GEOGRAPHICAL SOCIETY, LADIES AND GENTLEMEN :—I beg permission to call your attention this evening to a few of the interesting geographical features of our great West. It is fortunate that by means of the photographer's camera and the stereopticon, we can all travel together by physical, as well as mental vision, over this most wonderful region. Let us look for a moment at what we believe to have been the plan of growth of the physical history of the western portion of our continent. Prior to the explorations of Lewis and Clark, in 1803 and 1804, it was supposed that the Rocky mountains consisted of a single ridge or range, extending from north to south, or at least one main range, with a few minor ranges. And all the old maps were constructed on that plan. Our present knowledge reveals to us the fact that the name "Rocky mountains" is only a general and rather indefinite term, including an almost limitless series of ranges or folds like the waves of the sea. From the eastern slope we pass over range after range, for 1,000 miles or more, until we descend the western slope of the Coast range to the Pacific ocean. The greatest width of this remarkable series of ranges or folds, is near the 40th

parallel. Suppose that we were to glance at a profile of the country along the line of the Pacific railroad from Omaha to San Francisco. We shall be led to believe that the great area west of the Mississippi was originally an enormous plateau, out of which was evolved the different ranges of mountains as if thrust up by some volcanic force. According to the railroad level, Omaha is 966 feet above tide water; one hundred miles west of this point, the elevation is 1,470 feet, indicating a gradual rise of five feet per mile. At Cheyenne, near the eastern base of the Rocky mountains, 516 miles west of Omaha, the elevation is 604 feet, showing a gradual rise of ten feet per mile. From this point to Sherman, the highest point of the Laramie range, where the elevation is 8,242 feet, the distance is only thirty-three miles, and the grade is suddenly increased to sixty-six feet per mile. From Cheyenne to the Sierra Nevadas the general level of the plain country varies from four thousand to ten thousand feet, while some of the highest peaks attain an elevation of from fourteen thousand to fifteen thousand feet above the sea. Suppose we turn aside from our course for a moment and travel along the immediate base of the Eastern range. For one hundred miles to the southward we shall find that the great Colorado or Front range, of which the snow-covered summits of Long's and Pike's peaks form a part, rise abruptly out of what appears to be an almost level plain, and we shall see the various sedimentary formations elevated to view, as if the vast granite nucleus had been thrust up vertically, leaving upon its sides the sandstones and limestones of the more modern beds inclining at various angles. But we cannot stop here to solve the numerous problems which these magnificent scenes bring before the thoughtful mind, but hasten onward toward the great National park, at the sources of the Yellowstone and Missouri rivers. Crossing the Laramie or Front range, which is about twenty miles in width, we descend a gentle slope to the Laramie plains. Along the immediate line of the Pacific railroad we do not cross another range of mountains until we reach the Wasatch, which forms the eastern rim of the Salt Lake basin, and gliding through the Wasatch mountain, by way of the Weber Cañon, we soon arrive at Corrinne, 1,055 miles west of Omaha. In this long distance we pass over only two ranges of mountains and not over twenty miles in width of granite rocks. The Laramie plains differ in elevation in different parts from six thousand to seven thousand feet above the sea, and after passing the water divide at Creston, seven thousand and thirty feet above the sea, we gradually descend to the valley of Salt Lake, which is about four thousand four hundred feet above

tide-water. At Corrinne we leave the comfortable traveling by rail, and continue our journey northward by stage to Virginia City or Bozeman, Montana. While at some future period there may be nearer routes to our great National park, these are the most accessible approaches at the present time. The little town of Bozeman is located at the head of the Gallatin Valley, while Virginia City is about seventy miles to the south-west of it, on a branch of the Jefferson river. At either of these points an excellent outfit and guides can be procured for a trip through the park. If we make Bozeman the point of departure, we shall cross over the divide between the headwaters of the Gallatin and Yellowstone river into the Yellowstone Valley, and travel up that beautiful valley with its lofty, picturesque mountains on either side. A journey of sixty miles will bring us to the north boundary of the park, to the Mammoth Hot Springs, one of the most remarkable scenes in the world. We shall then continue on our way up the valley, stopping to admire the Tower Falls and other scenes until we reach the lake. Then over the divide again to the eastward we pass into the upper and lower Geyser basins, where the grand geysers are located, and then down the Madison Valley to Virginia City. If we were to make the latter place our starting point, the tour would be simply reversed. This round trip would comprise the principal objects of interest in the park. It would require from three to six weeks and embrace a distance of about 250 miles. I will now call your attention to some of the principal points in the geographical features of this most interesting region, as shown on the map of a portion of Montana. At the north side, near longitude $111^{\circ} 30'$ and latitude 46° , is a remarkable geographical point called the "Three Forks of the Missouri," the junction of the three great branches—the Jefferson, Madison and Gallatin—so named by Lewis and Clark in 1803-4. Rising in the high area about 100 miles to the south, the courses of the streams are very meandering, and they drain an area of about 100 miles from north to south and about 150 from east to west. They finally unite to form the Missouri within a few yards of one another. The elevation at this point is 4,132 feet, and rapidly increases toward the sources. These beautiful valleys were, in the pleiocene times, the basins of large fresh water lakes, the waters of which extended up to the foot of the mountains, and it is to these marly lake deposits that most of their beauty and fertility is due. In the autumn of 1872, as I stood at the entrance of West Gallatin Cañon, the view down the valley could not have been surpassed even in this land of picturesque scenery. The gently-rolling grass-covered bottoms, the little

streams meandering through them, fringed on either side by a thick growth of cottonwoods, the numerous farms, golden with their fields of wheat, and over all, in the distance, that peculiar soft golden haze which characterizes the autumn days in this mountain region, lend to the whole scene a charm that is long remembered. As the setting sun of an autumn day shines upon the valley and surrounding mountains, all objects seem to be invested with an unusual beauty, which reminds one of the lines of the poet —

“And sweet calm days, with golden haze,
Melt down the amber sky.”

At least fifteen or twenty small branches unite to form the Gallatin, which have their sources far up in the mountains. Mr. Jackson, the photographer of the survey, penetrated this region for the first time in 1872, and obtained in it some most marvelously beautiful views of the scenery. Palace Cañon and Palace Butte, which I now show you, are formed out of the stratified tuffs and breccia, and the palace-like forms were carved out of the solid volcanic material by the slow process of erosion by water. You see here the very birthplace of the mighty rivers that are ever flowing onward thousands of miles to the sea. The snows on the mountain summits supply the waters that are gathered by the myriads of little branches, finally uniting into one great river which flows down to the Gulf of Mexico, irrigating and fertilizing millions of acres of land in its course. But we must hasten on our way over the divide into the valley of the Yellowstone, and passing many objects of great interest, which our limited time will not permit us to notice here, we arrive at the north limit of the National Park, at the Mammoth Hot Springs on Gardiner's river. This little stream empties into the main Yellowstone from the east side, and as we wind our way up the valley, on the east slope of the mountains, we suddenly come upon one of the most marvelous groups of hot springs in the world. The sediment deposited by the springs is mostly calcareous. So that we have two classes of springs in the park — calcareous and silicious — the former depositing lime, and the latter silica. These calcareous deposits cover an area of about two square miles. The picture presents to the eye the appearance of a frozen cascade. A system of step-like terraces is formed by the water, that will ever defy any description by words; the eye alone can convey any adequate conception to the mind.

We have before us an illustration of the mountain slope, ornamented with a series of semi-circular basins or pools, with margins varying from a few inches to two feet in height, and so beautifully scalloped and adorned with a kind of bead work, that the beholder

stands amazed at this marvel of nature's handiwork. Add to this a snow-white ground, with every shade of color, pink and yellow, as varied as our aniline dyes, and the attractiveness of the picture is greatly intensified. The pools or basins are of all sizes, from a few inches to six or eight feet in diameter, and from two inches to two feet in depth.

As the water flows over the mountain side from one basin to the other, it constantly loses a portion of its heat, and the bather may select any temperature he may desire. The wonderful transparency of the waters of these springs surpasses any of those of the kind I have ever seen in any other portion of the world. The sky, with the smallest cloud that flits across it, is reflected in its clear depths, and the ultramarine colors, more vivid than the sea, are greatly heightened by the constant gentle vibrations. Although these springs are in a constant state of violent ebullition, emitting carbonic acid gas in considerable quantities, yet the temperature does not usually rise higher than one hundred and fifty or one hundred and sixty degrees, the highest being one hundred and sixty-two degrees. The old ruins that cover the larger part of this area are not the least interesting and important portion of their history. One high cone, which we call the Cap of Liberty from its shape, must have been a geyser at one period, but it is now extinct. The water must have been thrown up by a continuous succession of impulses, like a fountain, depositing by evaporation the sediment in the form of the overlapping layers which we see in the photograph. Finally it closed itself up at the summit and perished, and now remains a monument of the past. It is forty-two feet high and about twenty-five feet in diameter at its base. We might dwell for hours on these remarkable springs, but we must hasten onward. We will just glance at the curious illustrations of columnar basalt in the sides of the Yellowstone Cañon. The Lower falls with its grotesque beauty,—the tall gothic columns of volcanic breccia surrounding it like sombre sentinels. The Grand Cañon is about thirty miles in length, and has been carved out of the solid mass of trachyte, volcanic breccia and hot spring deposit. The Upper and Lower falls are within a quarter of a mile of each other. The Lower falls are three hundred and ninety-seven feet in height, while the Upper are not more than one hundred and forty feet. From the falls to the lake the distance is about fifteen miles. Groups of hot springs, mud puffs and wonderful steaming cauldrons meet us at every point. There are several groups, as the Crater Hills, Mud Geysers and other localities, comprising in all more than five hundred, of various degrees of importance. The lake itself, which is really the

source of the Yellowstone river, is about twenty-two miles in length from north to south and twelve to fifteen in width from east to west. The elevation of the lake is seven thousand seven hundred and eighty-eight feet above sea level, and its height may be, perhaps, better appreciated when we state that if Mount Washington was placed in its basin, the surface waters would roll fifteen hundred feet above its summit. To describe its wonderful beauty in detail here to-night would detain you too long. It is sufficient for me to say that it is not surpassed in the picturesqueness of its surroundings by any other mountain lake in the known world. High ranges of mountains, with their summits covered with perpetual snow, gird it on every side. Its greatest depth is three hundred feet. Its waters are full of trout. On the north-east side of the lake there is a group of hot springs, about three hundred in number. Several of them extend out into the waters of the lake and have built up cone-shaped mounds of pure white silica, and, being entirely disconnected with the surrounding cold waters, are at all times at boiling point nearly. In the cold water, trout weighing from one to three pounds are very abundant, and the traveler may stand on the silicious mound and hook the trout and cook them in a few minutes in the boiling hot springs under his feet. The divide between the Yellowstone and Snake rivers at one locality on the north side of the lake is not over three hundred feet above its waters, and the source of the Snake river comes up within a mile of the lake. The Atlantic and Pacific waters could easily be connected together. This is an interesting fact in a geographical point of view, but the idea of connecting the waters of the Atlantic and the Pacific for the practical purpose of transportation is a far-off vision of the future, when congress can vote fifty millions of dollars or more for the purpose without a murmur. The views from the mountain peaks around the lake are far-reaching and remarkable for their picturesque beauty. From the summit of Red mountain on the south side of the lake, ten thousand three hundred and forty-three feet above the sea, the scope of vision embraces a radius of one hundred to one hundred and fifty miles, within which over four hundred mountain peaks, ranging from nine thousand to eleven thousand feet in height, may be distinctly seen. This may also be regarded as the water apex of the continent. The general elevation is seven thousand to eight thousand feet, and within a radius of ten to twenty miles are the sources of three of the largest rivers on the continent. Flowing northward are the numerous branches of the Missouri and Yellowstone rivers. To the south are the branches of Green river, which, uniting with the great Colorado of the west, finally flows into the

Gulf of California, while south and west flow the branches of Snake river, which, uniting with the Columbia, pour their vast column of water into the Pacific ocean. From this mountain an area of not less than 50,000 square miles is swept within the circle of vision. Ten large lakes and several smaller ones, with the entire National Park, is spread out under the eye. This remarkable view embraces a large portion of Wyoming, Montana, Idaho and Utah territories. To the east we can see distinctly the Wind river and Big Horn ranges, with the snow-clad summits of Fremont, Union and Cloud peaks; on the north the Yellowstone range, with Emigrant peak, and many of the loftiest mountains in Montana; while to the west the numerous ranges comprised in what is known as Salmon River Mountains of Idaho bound the horizon; and to the south, in the Snake river valley, the vast range of the Tetons send their shark-tooth summits above the clouds, white with perpetual snows. We might linger here for hours, describing to you the varied and remarkable scenery of this unique region, but we will hasten over the water divide to the westward and descend into the source of the Madison. Here are located the two great Geyser basins of the world. In the upper Geyser basin are about fifty first-class spouters, any one of which would equal the far-famed Geyser of Iceland. The two basins are situated in the valley of a branch of the Madison, called Fire Hole river, a suggestive name. The two basins are about ten miles in length and a mile in width, on an average, with an interval of about two miles separating the basins. Within this area there are hardly less than 3,000 to 5,000 springs of all kinds. The valley is walled in with volcanic mountains rising fifteen hundred feet or more. Mr. Jackson, the photographer of the expedition, secured fine views of some of the most important geysers, some of which we have the pleasure of showing you this evening. Only one of them was taken while in action, and this was "Old Faithful." This geyser is located on a hill, at the very head of the valley, and has received its name from its fidelity to its periods of action, never failing to act once in sixty or sixty-five minutes through the twenty-four hours of the day and night. The commencement of the outburst is foretold by a rumbling noise beneath the crust, and then a column of water, six feet in diameter, is held up one hundred to one hundred and fifty feet for about five minutes. Time will not permit me to describe in detail the wonderful ornamentation around the springs, produced by the silicious deposits, nor the remarkable transparency of the waters in the calm springs, where all the colors of the rainbow are produced. Then there are the mud-springs, one

of which has a diameter of forty feet, and is constantly throwing up particles of silicious clay, fine enough, it would seem, for the manufacture of the finest ware. We might call attention to the remarkable cañon of the Madison, where the river rushes down between walls of basalt fifteen hundred feet high, and the unique terraces on the lower Madison Valley, but they must be seen by the traveler to be thoroughly appreciated. The peculiar beauty of this kind of wonderful scenery is its great variety. We pass from one unique scene to another, until the mind almost wearies with the marvelous as well as the picturesque. Before leaving this strange land, I beg to call your attention to one more interesting geographical point. You will see on the little map that is thrown on the screen, that at the head of Henry's Fork of Snake river, there are four remarkable passes or depressions in the great water divide or crest of the Rocky mountains. These passes may be regarded as representing the four points of the compass, and may be called the great gateways of the continent. The Reynolds, or North pass, leads into the lower Madison through a smooth, grassy valley, only six thousand nine hundred and eleven feet above the sea; the Tygee, or East pass, seven thousand and sixty-three feet, opens into the upper Madison, and thence to its source; the West, or Red Rock pass, seven thousand two hundred and seventy-one feet, connects the great valley of the Jefferson Fork with the Snake River Valley; while the South, or Henry's pass, six thousand four hundred and forty-three feet, connects all the others with the interior of the continent and the Pacific coast. The surface is so smooth in all these passes, that one may ride from the Pacific slope to the Atlantic in a coach and four at full speed. In a practical point of view, these passes will be of the utmost importance. The great valley of Snake river is very fertile, and may be made available for settlement at once; and the pine forests, which are almost unlimited in extent, might be utilized by means of railroads for the benefit of the almost treeless interior, of which Salt Lake basin is a part.

I have been able in this rapid journey to present only a mere glimpse of the remarkable scenery and striking geographical features of this wonderful region. We will now return to Colorado. The north line of the Territory lies along the parallel of forty-one degrees; the east line along the meridian of one hundred and two degrees; the south line on the parallel of thirty-seven degrees; and the west line along the meridian of one hundred and nine degrees. Within these limits are some of the most remarkable ranges of mountains on the continent. The Colorado, or Fort range on the east, the

Park range, the great Sawatch range—usually called the Sierra Madre, or Mother range, from the fact that it is the backbone or water-shed of the continent; the Elk mountains, farther westward, terribly rugged, with numerous sharp-pointed peaks rising over fourteen thousand feet. From the summits of the high peaks of any of these ranges, a perfect wilderness of mountain summits is embraced within the scope of the vision. Well may Colorado be called the “Switzerland of America,” except that the immense glacial masses have passed away. In Switzerland a half dozen or so of peaks, rising to fourteen thousand feet, may be seen, while from the summit of Mount Lincoln in the South park, which is itself fourteen thousand and one hundred and eighty-three feet above the sea, may be seen at least fifty summits rising from thirteen thousand to fourteen thousand feet and upwards. You will see by the illustrations thrown upon the screen, how the mountains extend from east to westward, range after range, like sea waves. The general elevation of the surface is from six thousand to ten thousand feet above sea level. The village of Fairplay, in the South park, is nine thousand seven hundred and sixty-four feet. Let us for a moment suppose ourselves at Denver, a city in the plains, about twelve miles east of the base of the Colorado mountains, but so near that the eye can take in this general range from Long’s peak at the north to Pike’s peak at the south, a distance of about one hundred miles. Denver is a little over five thousand feet in elevation. Looking to the west from Denver, when the atmosphere is clear, the immense massive Front range seems to rise suddenly out of the plains with such proportions, that it appears to dwarf all others that we have ever seen, when contrasted with the broad level plain. To the north, Long’s peak rises to the height of fourteen thousand one hundred and fifty feet, towering high above the surrounding mountains; the snows that cap its summit giving birth to streams that flow westward into the Pacific and eastward into the Atlantic. It may always be known by its summit being divided into two sharp crests, the western one being the highest. The rocks are granite schists. About twelve miles to the north-west, is a beautiful park four by six miles in diameter—one of the most beautiful watering places for invalids and pleasure-seekers in Colorado. The little Thompson creek, which rises in Long’s peak, and flows through the middle of Estes park, is filled with trout. These little parks are so close to the high ranges, and are so sheltered, that they form fine pasture grounds for herds of stock. As we look southward, Audubon, Parry’s, James’, Torrey’s, Grays’, Evans’, Rosa, and far south Pike’s peak, all rising over thir-

teen thousand, and most of them over fourteen thousand feet. Patches of snow are always seen above timber line, which is there about eleven thousand feet. Along the eastern base of the front range are a series of singular uplifted ridges, usually called "Hog Backs," which are oftentimes weathered into remarkably unique forms. These ridges are the upturned edges of the entire group of the sedimentary rocks known in this region from the Silurian to the Tertiary inclusive, which, prior to the elevation of the mountain ranges, extended uninterruptedly across the area now occupied by them. They have been brought to the surface by the upheaval of the great granite nucleus. The "Garden of the Gods," near the east base of Pike's peak, is formed by the weathering of the red Triassic sandstone into singular forms. There is an opening through one of the nearly vertical ridges called the "Gateway to the Garden," through which Pike's peak, with the intervening lower ranges, are distinctly seen. On the summit of Pike's peak the Signal Service Bureau has established a station, and weather reports, from an elevation of thirteen thousand nine hundred and eighty-five feet, are transmitted daily to the office at Washington. Monument park is another interesting locality near Colorado Springs, where the Tertiary sandstones have been worn by atmospheric agencies into curious columns, capped with a brown, hard mass of rusty iron stone. The illustration will show to the eye, more clearly than any description, the variety of forms these rocks assume. Although these massive ranges of mountains seem to the eye at a distance to be almost inaccessible, yet there are roads winding about among them in every direction. Ranches, and even little thriving mining villages, are hidden away in the little sheltered parks walled in by the high mountain peaks and ridges. Let us enter the mountains by one of these roads which follows up the cañon of Clear creek to Georgetown, a little village of about two thousand inhabitants, built up by the silver mining interests in the vicinity. If we follow the same stream twelve miles farther, we shall reach its source at the east base of Gray's and Torrey's peaks. We may follow a well-trodden path on foot or on horseback to the summit of Gray's peak, fourteen thousand two hundred and fifty-four feet above the sea. Separated from Gray's peak to the north by a saddle, about a mile distant is Torrey's peak, fourteen thousand two hundred and forty-nine feet. These splendid peaks were so named by Dr. Parry, several years ago, in honor of the two great American botanists — co-workers in the same branch of science for so many years. There is only five feet difference in the heights of the peaks. There seems to have been a beau-

tiful fitness in attaching these names to these two peaks, and they will ever remain enduring monuments to their fame.

From the summit of Gray's peak we can embrace a large portion of the mountain region of Colorado, within the horizon of vision. The splendid parks — North, Middle and South parks — are spread out to view. These great parks are really depressions underlaid with the sedimentary beds, but surrounded on all sides by high ranges of mountains. South park is about thirty miles in diameter from north to south. The drainage is entirely from north-west to south-east and east. The general elevation of the park is from nine thousand to ten thousand feet, and, on this account, while the broad, level basin in midsummer is covered with high grass like a meadow, the climate will always be too severe for the successful cultivation of crops of any kind. The Middle park, which lies directly north of the South park, is far more complicated in its structure. It is really composed of a number of small parks, which were, in comparatively modern times, geographically speaking, fresh water lake basins, the old lake deposits still remaining to reveal the history of the later physical changes. The general level of this park is greater than that of the plains to the eastward of the mountain ranges. Still the sedimentary groups of strata are the same. They shared in what may be called the general elevation, but the great lines of fracture of the earth's crust are those along which the most powerful forces acted. To the eastward from Gray's peak we can look off on to the plains, our vision only limited by the horizon. To the north we take in the splendid line of snow-covered peaks of the Colorado range; to the west and south-west the mountain of the Holy Cross and the lofty peaks of the Park range. If we were to describe all the interesting localities in detail, which come within the circle of our vision from a single peak, it would occupy the entire evening. We may look down the valley of Clear creek, which rises at our feet, and we shall see one of the most active mining districts of the West. The mountains are veined, like the human body, with silver, and on the almost vertical sides, sometimes 1,500 feet above the valley below, may be seen the miners' houses spiked on to the granite rocks. Tunnels have been partially completed through many of the mountains, and excavations from base to summit are so numerous that, to compare great things to small, we might be reminded of the burrowing of squirrels. Beautiful lakelets meet the eye on every side, sometimes far up above timber line. Perhaps the most picturesque lake in Colorado is the one that lies at the foot of Mount Rosalie and forms the source of Chicago creek. It is a favorite place of resort for visitors and especially artists. A dozen or more

of these little lakelets may be seen from this point, lying at different elevations. The great peaks usually lie along a certain line or axis, which forms a water divide. On either side of this water divide are huge amphitheatres, in which are accumulated great bodies of snow, which, during the summer, are continually melting, filling up the little lakelets or reservoirs below. All the myriad branches of our mountain streams rise in an amphitheater, and in almost all cases have their immediate sources in one of these little emerald-green lakes. These amphitheatres are formed by the constant tendency of the elements for ages past to excavate toward this mountain crest or divide. Water and ice have been the great agents. The water from the melting snow accumulates in the fissure of the rocks, and freezing, pushes off, by expansion, layer after layer, until the sides of the mountains for miles are covered with the débris. In many instances the crest has been, as it were, eaten through, so that low saddles or passes are formed. The great work of destruction, or the leveling down of these mountains, has been going on for infinite ages, and although in past time the destructive forces were vastly more effective, yet the slow process still goes on. The highest ranges have felt most the power of those eroding forces. This is what may be called "earth sculpture," and it is to the marvelous skill of nature in this, her artistic work, that the picturesque scenery of the Rocky mountains is due.

There are some quite remarkable forms among these amphitheatres, and we may mention the "Horse Shoe" in the Park range, which has been slowly excavated for at least five miles back from the plains, to the very crest of the divide. The Park range forms the west wall of the South park, and its axis trends about north-west and south-east. In what is called the Mount Lincoln group are six peaks that may be ranked in the first class, three of which are respectively 14,183, 14,047 and 14,055 feet, viz.: Lincoln, Quandary and an unnamed peak, and Buckskin and "Horse Shoe" peaks, 13,951 and 13,780 feet in height. These mountains are covered with silver mines. On the summit of Mount Lincoln, one of the most valuable mines in that district, with all the necessary buildings, is located within one hundred and fifty feet of the top. A road has been made to this mine. Many of the high mountains, instead of sharp angular crests and ridges, are covered with a heavy bed of soil, so that their forms are smoothed and rounded, and covered in many cases with herbaceous vegetation far above timber line. For fifteen hundred feet above timber line on Mount Lincoln and the surrounding peaks, there is in July and August a thick mass of beautiful spring flowers of great variety and hue. It is very seldom that so fine a

floral exhibition can be found in lower and more favored regions. Many of these beds of flowers are surrounded with perpetual snows. Just west of the Park range is the great Sawatch range, the Sierra Madre or "Mother range" of the continent, with a trend about north-west and south-east, and with a length of sixty to eighty miles, literally bristling with sharp peaks the entire distance, ranging from 12,000 to 14,000 feet and upwards. Between the Park range and the great Sawatch lies the Arkansas Valley, which in some respects is the most instructive in Colorado. Near the north end of the Park range is a modest mountain peak called "Triaqua," from the fact that it gives rise to three important streams. The Blue river, that flows northward from it, and trending toward the west, unites with the Grand or Gunnison river, and finally joins the great Colorado.

The Arkansas, which flows south from this peak about fifty miles, and then bends to the east, cuts through the mountains and opens into the plains; also the South Platte, which flows to the south-east, across the South park, and suddenly bends around to the north-east, cuts a deep cañon through the Colorado or Front range, and opens into the plains south of Denver. Let us now for a moment take a rapid glance at the principal features of the Sawatch mountains, one of the grandest ranges in America. Let us suppose ourselves standing upon the summits of one of the high peaks of the park, say Mount Lincoln. As we look westward, the sharp crests of the numerous lofty peaks are set like a forest along a belt of fifty miles or more in length, and about twenty miles in breadth. To the south we see the lofty summits of Harvard, Yale and Princeton, respectively 14,270, 14,041, 14,057 feet high, all surrounded by groups of peaks from 12,000 to 13,000 feet and upwards. To the northward is Elbert peak and Massive mountain, each over 14,000 feet. In this range we measured several peaks which reached an elevation of over 14,000 feet, while those of 12,000 and 13,000 feet and upwards were almost without number. At the extreme northern end of the Sawatch range is one of the most remarkable groups in the West, which we have called the Holy Cross group, the central peak of which is called the "Mount of the Holy Cross." In the topographical survey of Colorado during the past summer, this peak was made one of our most important stations, and was therefore carefully measured. It did not prove to be as high as we had expected, being only 13,540 feet, while we were led to believe, from its location on all existing maps, that it was probably 15,000 feet or more. We found it to be some thirty miles out of place. The difficulties which we encountered in the exploration of this interesting region will always prove an

era in the history of the survey. To reach this peak we ascended the Arkansas Valley, and crossed the water-shed at Tennesse Pass, descended Eagle river over one of the most rugged districts we have ever seen in the West, until we came to the mouth of Roche Montonne creek, a small stream which rises on the north side of the group, and flows to the east of north about ten or twelve miles, when it joins Eagle river. The valley of this stream is a vast glacial trough filled with rounded masses of granite, which are called, in the Alpine regions of Europe, *Roche Montonne*, or "Sheep Backs," varying in length from a few feet to several hundred, and crowded as thickly as possible. The sides of the mountain, for 1,500 feet in height, show the intensity of the glacial erosion. Much of the surface of these worn granites is now covered with a sort of smooth enamel which might be called a glacial crust. Among these rocks there is a perfect network of fallen timber, which renders traveling next to an impossibility. The autumnal fires have swept through the pine forests, and then the winter and spring winds have prostrated them in every direction. We could not reach the mountain with our animals within five miles, so that all the apparatus for triangulation and photography had to be carried by hand across five miles of rugged rocks and fallen timber before we began the ascent. Messrs. Gardner and Jackson were thirty-six hours without food or shelter in ascending the peak, and performing the necessary work from its summit. The views of the Holy Cross, which I present to you to-night, were taken from a ridge opposite, about a mile distant, 13,000 feet above the sea. The cross is formed by the snow filling up the huge cross fractures in the granitic mass. The vertical fissure is about 1,500 feet long, while the horizontal one is about 800 or 900 feet. At the time the picture was taken in August, much of the snow had melted out of the fissures, so that it is not quite so conspicuous as in the early spring or autumn. Before leaving the Sawatch mountains, I must call your attention to the wonderful moraines that occur on either side of the range.

The valley of the Upper Arkansas for fifty miles on the east of the range, and the valley of Taylor's creek on the west side, were once the seat of enormous glaciers, filling up the valleys and extending up the side cañons far up to the very crests of the mountains. The Twin lakes are glacial basins surrounded by moraines. The two lakes, which are only a few hundred yards apart, are separated by morainal bridges. These beautiful lakes are located close to the base of the mountain between two high morainal ridges 700 to 800 feet high. The upper one is about one and a half miles in diameter and eighty

feet deep. The lower one is about three miles long and is seventy-six feet in depth. In the valley of Clear creek the moraines on either side rise 700 feet, and look so regular that they have the appearance of huge railway embankments. In the deep cañons, which have been carved out of the mountains up to the very crests, marks of the glacier may be seen for 1,500 feet in height. So far as the structure of this mountain region is concerned, we may say, in general terms, that the great Sawatch range forms the central granitic nucleus of a grand anticlinal, with the Arkansas Valley on the east side and Taylor's Valley on the west, as monoclinical depressions, and the Park range on the east side of the Arkansas Valley as one of the subordinate ridges inclining toward the east from the central axis, while far west of the main range the sedimentary rocks incline in the opposite direction; therefore both the valleys of the Arkansas and Taylor's river are partially the result of erosion and partially of original fracture in the uplift of the great granitic axis. I will call your attention to but one more range of mountains; this is the Elk range, still farther to the west, in the drainage that leads to the great Colorado of the West. This range is about fifty miles in length and differs from any of the others in its form and structure. In this range are seven or more peaks of the first order, rising to an elevation of nearly 14,000 feet, and many others ranging from 12,000 to 13,000 feet and upwards. But it is the peculiar geological structure of this Elk range that attracted our attention more especially. It would seem that at one period the great group of sedimentary rocks, comprising many thousands of feet in thickness, rested on a floor of igneous granite, in a pasty or semi pasty condition, and that these high peaks of granite were thrust through these overlying strata, in many instances completely overturning them, so that there are two series in contact. A series underneath, rising layer by layer in regular order, from the silurian to the cretaceous inclusive, and then the series reversed, with the silurian on the summits. This complete overturning of the entire sedimentary group continues for ten or fifteen miles without interruption. Sometimes the sedimentary beds are lifted up at great elevation from the summits of the highest peaks, with portions faulted down in the lowest gorges, so that corresponding portions are broken off, producing faults of 2,000 feet or more. Deep gorges and amphitheatres meet the eye on every side. Snow Mass mountain, 13,853 feet above the sea, is so called from the immense mass of snow which ever lies on its sides, rendering it conspicuous at a great distance; and at its immediate level, on all sides, are nestled beautiful lakes which receive the waters from the melting snows. No

one can convey to you the marvelous ruggedness of the surface. As far as the eye can reach, on every side, may be seen high mountain peaks with deep gorges in one continuous succession, while the sedimentary rocks are thrown into utter chaos. The survey under my charge during the past summer measured seventeen peaks in Colorado which reached an elevation over 14,000 feet, and twenty-seven over 13,000 feet, and an almost indefinite number rising above 12,000. There can hardly be less than twenty-five peaks in Colorado that rise above 14,000 feet, and thirty or more that are over 13,000 feet in height, so that Colorado may well claim to be the mountain region of America. I might dwell for hours on the details of the remarkable geographical features of this wonderful country, but I have already prolonged this lecture beyond the usual time. If the surveys which have been inaugurated by our Government are permitted to continue, we may annually look for fresh and most valuable additions to our knowledge of the geology and geography of the little-explored portions of our great West. May the united voice of the people go up to our legislators in Congress, and sustain them in their efforts to continue them, until it shall not be thrown up to us as a matter of reproach that even Central Africa is better known to geographers than our own great West.

Prof. Theodore W. Dwight moved that a hearty vote of thanks be given to Dr. Hayden for his valuable and instructive paper.

Unanimously adopted.